IMPROVING FIREFIGHTER ACCOUNTABILITY SYSTEMS WITH THE USE OF ELECTRONIC DEVICES

LEADING COMMUNITY RISK REDUCTION

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CERTIFICATION STATEMENT

I hereby certify that this paper constitutes my own product, that where the language of others is set forth, quotation marks so indicate, and that appropriate credit is given where I have used the language, ideas, expressions, or writings of another.

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Abstract

The research problem was that electronic accountability systems are not used to locate firefighters within a structure. The purpose was to improve the accountability systems by the use of electronic data, by tracking, locating, and being returned safely. The evaluative research methodology was used to answer: 1. What types of accountability systems are available? 2. What is the reliability of the current systems? 3. What improvements can be made? The procedures included literature on the regulations, products, and testimonials about accountability systems. The results proved that no one type of accountability system could do it all. The recommendation is that the fire service continues to look for more reliable, safer ways to track individuals on an emergency scene.

Table of Contents

Abstract ..... page 2

Table of Contents ..... page 3

Introduction ..... page 4

Background and Significance ..... page 5

Literature Review ..... page 8

Procedures ..... page 20

Results ..... page 22

Discussion ..... page 26

Recommendations ..... page 29

Reference List ..... page 30

Improving Firefighter Accountability Systems

With the Use of Electronic Devices

Introduction

Through the history of firefighting, lives have been lost due to the inability to locate a firefighter within a structure when he or she is in trouble. The City of Stuart's current accountable system uses plastic individual identity tags that are stuck to the back of the helmet for accessibility. When reporting in on an emergency scene, they are removed and handed to the Incident Commander or his designee. These individual identity tags are then placed on an accountability board used to manually track the location of the firefighter during emergency operations. The City of Stuart also employs Personal Alert Safety System (PASS) devices on each of the air packs.

Craig A. Walker describes the problems with the current accountability systems by stating that many firefighters have died in fires by not activating their PASS devices. Along with the PASS devices comes the necessity that the current tracking systems can be difficult to manage on a large incident. "When one or more of the components is not performed, the system fails and there is no true personnel accountability. Sadly, this often leads to tragedy" (Walker, 2006, ¶8).

The problem is that the City of Stuart does not use an electronic accountability tracking system to locate firefighters within a structure. The purpose of this research is to identify options to improve the accountability system for firefighters within a structure, by the use of electronic data, which will allow them to be tracked, located, and returned to safety.

The evaluative research methodology was used to answer the following questions:

1. What types of electronic accountability systems are available to fire rescue personnel?
2. What is the reliability of the Stuart Fire Rescue's current accountability systems?
3. What types of improvements can be made to the electronic accountability systems to reduce firefighter deaths and injuries?

Background and Significance

Firefighters have always been at risk of losing their lives while fighting fire. The National Fire Protection Association (NFPA) has developed standards to help prevent the loss of life, which requires emergency service organizations to adopt an incident management system to manage all emergency incidents (NFPA 1561, Chapter 5.1.1). The National Fire Protection Association defines accountability as "A system or process to track resources at an incident scene" (NFPA 1561, Chapter 3.3.1). Under NFPA 1500, Chapter 8, Emergency Operations (2006), the guidelines for accountability are referred to in NFPA 1561. The NFPA does not specify which type of system to use, but regulates: that fire departments have a means for rapid accounting of all responders at the incident; that they employ specific means to identify and track responders entering and leaving hazardous areas; that there is a means for the tracking of responders to geographical or functional areas; that all personnel can communicate with the incident management system their location and relocation at the incident; and that a standard operating procedure be developed and implemented to evacuate responders from an area where an

imminent hazard condition is found to exist and to account for the safety of responders (NFPA 1561, Chapter 5.2 Resource Accountability).

The United States Fire Administration publishes a fatality report every year describing the cause of fatalities within the fire service. In 2005 there were six fatalities involved in fire. Although they may not have all occurred due to error in the accountability system, there is one particular case, *Career Captain Dies After Running Out of Air at a Residential Structure Fire—Michigan*, that NIOSH investigated and reported recommended actions. The report states, "a 39-year-old male career Captain (the victim) died after he ran out of air, became disoriented, and then collapsed at a residential structure fire" (NIOSH, 2006b, ¶1). The report gives details of the fire and a reenactment of the events. Prior to entering the structure, the Captain did not do a proper survey of the home. The report goes on to say that the Captain did not wear his self-contained breathing apparatus properly, he did not remain with his partner throughout the search and rescue operations, and he did not use the proper communications to call for help. Although the Captain did have a hose line upon entry, he did not remain connected to the line during his search and rescue operations. The Captain was eventually found with the PASS device working but it was unable to be heard because he was lying on top of it (NIOSH, 2006b).

This incident is a perfect example of how the City of Stuart Fire Rescue's current accountability systems may not be good enough. The City of Stuart Fire Rescue is a two-station, 38 member department. The City of Stuart is the hub of Martin County, Florida and is made up of business and residential communities. Each member is issued a radio, accountability tags, and protective equipment. The vehicles are equipped with Mine

Safety Appliances Company (MSA) breathing apparatus using an integrated PASS device. If this incident were to happen with the City's system, it could produce the same results. If the PASS device was not heard, and even if command knew there was a firefighter trapped in the building, there would not be a way to determine exactly where the victim was located within the structure.

Since the National Fire Protection Association has required firefighter accountability, it is imperative that the City of Stuart Fire Rescue research to find if there is a more reliable system available. As discussed in the United States Fire Administration's Executive Development course, and again in the Leading Community Risk Reduction course, leaders in the fire service are encouraged to have a vision, develop plans, and to research problems and find solutions to benefit their department, which in turn may benefit other departments with similar problems (U.S. Fire, 2004). One of the United States Fire Administration operational objectives is to "reduce the loss of life from fire of firefighters" (U.S. Fire, 2003, p. II-2). It is believed that this research will enhance the accountability systems currently used by the City of Stuart Fire Rescue, and may assist other fire departments in enhancing their current accountability systems.

It is critical that all fire departments take the initiative to reduce firefighter fatalities; thereby leading the community in risk reduction. As stated in the United States Fire Administration's Leading Community Risk Reduction Student Manual:

> The impact from fire is reduced in the community. As a result of the interventions many fires now are prevented from ever occurring. Also, the impact from the fires that do occur is minimized. This results in lower fire frequency, fewer injuries,

> fewer deaths, and reduced property loss. These outcomes are truly the bottom line for community risk reduction. (2005, November, p. SM 0-17)

The goal of this project is to research the current technology available and determine if it can exceed the reliability of the accountability systems presently used by the City of Stuart Fire Rescue. Although there has never been a firefighter's life lost due to firefighting in the history of the City of Stuart Fire Rescue, it is imperative that this will never happen. The seriousness of the loss of a life is the utmost importance and the driving force of this project.

Literature and Review

The National Institute of Occupational Safety and Health (NIOSH) and the Occupational Safety and Health Administration (OSHA) were developed by the Department of Health and Human Services. "The National Institute for Occupational Safety and Health (NIOSH) is the federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness" (NIOSH, 2006a, ¶1).

> OSHA is in the U.S. Department of Labor and is responsible for developing and enforcing workplace safety and health regulations. NIOSH is in the U.S. Department of Health and Human Services and is an agency established to help assure safe and healthful working conditions for working men and women by providing research, information, education, and training in the field of occupational safety and health. (NIOSH, 2006a, ¶2)

The City of Stuart Tactical Guidelines addresses an accountability system that follows the NFPA Standards (City of Stuart, 2001).

The firefighter accountability systems available on today's market vary as described in a report published by IOCAD Engineering Service, Inc. for the U.S. Fire Administration, Federal Emergency Management Agency (1999). The manual called Personnel Accountability System Technology Assessment, lists all of the different types of accountability systems available to firefighters. The different types of manual personnel accountability systems (PAS) are as follows: (U.S. Fire, 1999, pp. 11-16)

1. Radio Rollcall—each person, or group of people has radio contact with command.
2. Clipboard and Paper—a person physically tracks each person entering and exiting the emergency scene. This can be a disadvantage if it gets wet.
3. White Board—board with dry-erase marker that works like a clipboard and paper but easily erases and data can be changed. This can be a disadvantage in the rain.
4. Ring-Based—a ring with tags that hold the individual's name and information that can be left with the PAS officer upon entering the hazardous area.
5. Hook-and-Pile—a tag system that uses two pieces of fabric to attach to gear and a command board.
6. Card-Punch Technology—similar to a time-keeping system where the card holds all the information about the firefighter and is given to the PAS officer upon entering a hazardous area.

The different types of electronic assisted PAS technologies are: (U.S. Fire, 1999, pp. 17-22)

1. Bar-Code Technologies—a bar code is placed on the gear that firefighters wear. When the person goes from one assignment to another they are scanned for documentation of their location. The benefit of bar-coding is that they can contain a great deal of information. The disadvantage of this electronic system is that it is no better than tracking manually.
2. Radar Technology—radar can detect a person breathing on the other side of a door or wall. This system can scan a large area quickly; however, it cannot penetrate solid metal areas.
3. Trapped Miner Location System—uses "geophones" to listen to tapping noises to locate a person trapped. The disadvantage of this system is that it is a recovery system and not a tracking system, and also it is extremely large and must be mounted on a tractor-trailer.

Examples of radio frequency technology are: (U.S. Fire, 1999, pp. 23-32)

1. Radio-Transmission-Based Accountability Systems—are actually manual systems that use the radio communications to help the incident commander stay in contact with firefighters and log their locations on a command board.
2. Radio-Frequency Identification Accountability Systems—sends signals to the command post, where a receiver is located. This is being further modified to send information to command. The firefighter would wear a

transmitter of some sort and the information would be transmitted to command. This technology has not been fully developed yet.

3. Radio-Frequency Motion Sensors—radio frequency signals are transmitted through nonmetallic objects to scan for movement on the other side. The downside is that the person must be moving, and this has taken place after an incident.
4. GPS-Based Accountability Systems—are global positioning systems (GPS) that lock in the precise latitudinal/longitudinal coordinates of a receiver.

There are many personal alert safety system (PASS) devices used by the fire service today. NFPA 1500, *Standard on Fire Department Occupational Safety and Health Programs*, requires all personnel involved in hazardous duties wear a PASS device. The problem is that many rescue workers have been found to not activate their system. To address this problem, manufactures are trying to overcome this problem by developing the following PASS devices: (U.S. Fire, 1999, pp. 33-37)

1. SCBA-Integrated PASS—is automatically activated when the self-contained breathing apparatus (SCBA) cylinder is turned on.
2. Partially Integrated Units—are mounted to the SCBA by a bracket and are activated when the air is flowing to the cylinder, the PASS can be removed from the bracket and activated manually.
3. Fully Integrated Units—must be mounted to the SCBA, and are activated by opening the air vent on the cylinder. These devices cannot be removed from the SCBA device.

4. Temperature-Sensitive PASS Devices—are designed to sound an alarm when exposed to temperatures around 450° for 1½ minutes, or at a lower temperature for a longer period of time.
5. Electronic-Transmitting PASS Devices—are devices that transmit a signal to a receiver, which alarms when the PASS device has been exposed to extreme temperature, or when there is a lack of motion for a short period of time. The PASS devices can include pertinent information about the individual wearing the device if programmed accordingly. The device transmits a signal every ten seconds to the receiver while in range. This way the person can be tracked when used in a large area.
6. Key-Activated PASS Devices—have a key that is removed to activate the device, and the key is given to command to use for accountability. This insures that all devices are activated when reporting to the scene.

Electronic Status Monitors play another roll in accountability. There are several types of status monitors used by the military to track a person's vital signs. The system has not yet been developed for emergency responders, and would also need to be used in conjunction with GPS to be a total accountability system. "In the future, it is hoped and expected that advances in positioning technology, such as GPS or radar, will be combined with these devices to provide a more complete picture of the location and status of any individual or group. Future models also are expected to be able to sense when an injury occurs or a wound is inflicted" (U.S. Fire, 1999, pp. 39).

There are other devices designed to assist firefighters with accountability by increasing overall scene safety: (U.S. Fire, 1999, pp. 45-51)

1. Sound-Based Exit Device—is a light beacon and sound device that transmits a sound every ten seconds. This device is placed by the exit of the structure so that if firefighters are lost or disoriented they can locate the exit. This device is audible for approximately 100 feet in most structures. This device can also be set to a firefighter distress signal.
2. Thermal Imaging Technology—is a camera device that uses infrared technology to sense different heat levels. They can be used to find trapped victims, trapped emergency personnel, and where the heat source is located.
3. Reflective Hose—is a luminescent hose that has directional markings on it to show the way out of a building. This hose will illuminate when a flashlight is shined on it and will assist the firefighter for the direction out, if used properly.
4. Reflective and Lighted Rope—are ropes that either have filaments that reflect light or contain lights within the rope.
5. Reflective Clothing—contains elements that reflect light and can be seen from as far as ½ mile away when light is shined on it. This reflective material assists people in seeing others during an emergency operation.
6. Light Indicators—are small lights worn on emergency personnel. The lights can either have a flashing light or a continuous light, but are used in the aid of locating others in dimly lit areas.

Other aids for personnel accountability are in the line of communications. These systems are limited due to distance, physical or electrical barriers, and can be blocked by walls and metal: (U.S. Fire, 1999, pp. 53-62)

1. Radio Frequency Systems along with Trunked Radio Systems—are the most common forms of communication throughout the fire service. The portable radios are relatively small and can travel a reasonable distance through concrete, which is important during emergency operations. The trunked radio systems allows for repeaters and longer travel distances. It also allows for multiple agencies to work together on several separate channels. Portable systems are only about 95% reliable.
2. Hardwired Communications Systems—are the most reliable for communications. The main drawback of a hardwired system is that it is always connected through a line, which limits the mobility of the worker in many emergency operations. A hardwired system is not practical for the fire grounds, but may be very useful for diving operations and confined space operations.
3. Communications Wire/Rope—are used in operations where a safety line must be attached to the responder. The rope is tied to the responder during rescue operations and can be used if the rescuer needs assistance getting out of the situation. The communications wire/rope is designed so that the technology is protected within the ropes synthetic fibers and is waterproof. The rope can be connected to a radio, headset, or other communications console.

4. Cellular and Satellite Technology—has proved to be extremely important after communication cables have been damaged after a natural disaster or due to a break in the line. Cellular receivers still must be put in place, even if only temporarily to receive cellular calls. A satellite telephone can be used when all other communications are not possible. Satellite telephones are expensive and larger than cellular telephones, but can be used in the most remote locations.
5. Real-Time Video Transmitter—takes live video from a camera and transmits it over microwave technology to a receiver. Most frequently the technology is used in a helicopter and then transmitted to the ground. This is extremely helpful in wildland fires where there is large area to cover and great definition is needed.

Since the publication of *Personnel Accountability System Technology Assessment*, technology is ever changing. There are numerous accountability tag systems available. All with just a slightly different twist, whether it is the amount of information on the tag, the durability of the tag, or the way the tag is attached to firefighting gear. The newest technology is working to improve the accountability systems by elaborating the barcode devices, radio transmitting devices, GPS, video, cellular, satellite, and thermal imaging devices.

Chief Jamie Carter (2005), states that his department's accountability system works well because firefighters are trained, they have a standard operating procedure in place, and they use the system. The system is a three-tag system used to track individuals along with their assignments on an accountability board. The procedure dictates that there

is always a safety officer designated on scene that utilizes an accountability board and tracks all the personnel on scene with the tag system. "The Safety Officer needs to be someone who is reliable, knowledgeable, and must be allowed to intervene when a safety issue arises. We always attempt to use an officer in this position, but any responsible firefighter may be used" (Carter, 2005, ¶10).

FieldSoft, Inc. (2003) believes they have the answer for tracking firefighters. In 2003, FieldSoft, Inc. paired up with Motorola to develop a firefighter accountability monitoring system. The system is called FDonScene Interface to Fireground and allows firefighters to use their Motorola radio to send a distress signal and the command unit will have access to a handheld computer that will alert them of the person carrying the radio and their individual information. "Together the companies are leveraging their combined skills to develop a leading edge firefighter safety and survival system that will be easy to use with a fully automated voice and data system to replace cumbersome 'dog tags,' plastic 'passports,' or 'marker boards'" (FieldSoft, 2003, ¶2). FieldSoft is actually a software package that allows many systems to interface with other software systems (FieldSoft, 2002).

Grace Industries, Inc. (2006) has produced a product called GEM System in which there is a PASS device and a receiver. "GEMS System's LCD Command Receiver employs visual and audible warning that a firefighter's T PASS II™ alarm has been activated" (Grace, 2006a, ¶2). Walker (2006, ¶2) states, "One problem found to be universally present was that the majority of fire/rescue personnel did not activate their PASS device because of this audible signal and the nuisance it created." The T PASS II™ generates an electrical charge from the motion of the firefighter wearing it. When the

GEM System is in place the PASS devices are automatically activated when they are in range of the receiver. This eliminates the possible chance that a responder has forgotten to activate the device. The alarm button is either activated by a lack of movement or can be manually activated by the firefighter. The PASS devices contain personal firefighter information that will benefit command if an evacuation should be activated (Grace, 2006c).

Captain Whelan (2001) describes the bar-coding accountability systems as "Express-lane accountability." The bar coding system allows each individual to be tracked through a bar-code placed within the bunker gear (protective clothing used by firefighters). The data contains pertinent information about the people and their qualifications. The bar-code then can be read by a scanner built into an industrial Personal Digital Assistant (PDA) that is portable, affordable, and easy to use. "One primary concern with implementing a new personnel accountability system is its compatibility with mutual aid departments' systems. There are more than 50 cities in the Dallas/Fort Worth metroplex area, and those cities use similar manual PASS systems. With the bar-coding system, D/FW is able to use the information on an accountability tag to create a bar code. The bar code then is adhered to the tag so the next time mutual aid is requested, responding firefighters already will be in the system" (Whelan, 2001, How it Works section).

Scott Health and Safety developed the Scott Electronic Management System (2006), which has integrated a transceiver built into air-monitoring regulator mounted on the shoulder harness. The receiving device monitors all air packs that are turned on and up to ½ mile, depending on building structures and topography. The equipment

transmits on the designated public safety frequency so that other radio traffic will not interfere with transmissions. "If no movement is detected after the pre-alarm is triggered, the system goes into full alert, emitting a 95dBA, 3-toned alarm and flashing red LED signal. After acknowledgement by the base station operator, 'PASS' is displayed on the shoulder console to assure the wearer that the signal has been received" (Scott 2006, Multiple Sensors section). While the system is activated the personal device will indicate the air level in the tank and also an alarm warning if the air is running out. All of the information is sent to the base monitor so that each firefighter is being tracked with their air consumption (Scott 2006).

Captain M. Tobia (2005, History Repeating section) writes in Fire Chief's magazine, "Functional fireground accountability is everyone's responsibility. Ultimately, the value of an accountability system is based on its ability to track the movement of firefighters into and out of the hot zone." Malcolm Beyer, Jr., (2006) Chairman of Advanced Ground Information System, Incorporated (AGIS), suggests the use of the newly patented *Many-to-Many* system for tracking individuals (personal communication, January 18, 2006). This new technology uses 3G Cellular/WiFi technologies to give "true high speed digital communications; transmission of video and photographs, communications security; precision GPS; reduced vulnerability to multi-path effects; and with low power, low weight, small size, long battery life" (Beyer, 2006a, Advantages of 3G Cellular/WiFi Technologies section). This system enables other software to be interfaced with it to obtain multiple benefits. "AGIS's network and display software use standard or 'ruggedized' PDA cell phone to provide location and status of each First Responder to all other Fire Responders." (Beyer, 2006a, ¶8). The software, when used in

conjunction with GPS and mapping, allows all individuals to communicate by phone, radio, or text messaging. The PDA device will allow communications with many parties at the same time or individually, hence the term *Many-to-Many*. "Examples of AGIS's capabilities include the ability to:

- Declare an emergency situation that is digitally relayed and displayed on all other users' PDAs with an accompanying verbal alert "Emergency".
- Call others by pointing at their symbols on the PDA display "Point to Call".
- Push text, photographs and videos addressed to other users and to cause the other users to be notified by a voice alert of the arrival of the photograph.
- Form communications nets so that people can voice or data conference together with a single switch action" (Beyer, 2006b, ¶7).

Yaccich (2006, ¶6) suggests that electronic systems are just tools. "You still need a human to operate it." Tino Yaccich has worked with accountability systems for over ten years. He has helped design systems for very large departments and also very small departments. He believes, "it is more important to have a good accountability officer to run your system, than it is to have an elaborate system" (Yaccich, 2006, ¶6). He strongly suggests you have a system that works, no matter how simple the system may be (Yaccich, 2006).

Captain M. Tobia (2005, History Repeating section) writes in Fire Chief's magazine, "Without people, an accountability system is useless as the halligan bar [firefighter multipurpose prying tool] in a compartment or an air pack in a seat.

Command officers who are committed to bringing their firefighter home alive must be able to answer the question: Who is in the building?"

Procedures

To accomplish this research study, a gathering of information from the National Fire Protection Association was used to find the appropriate guidelines for firefighter accountability systems (2006a & 2006b). The National Institute of Occupational Safety and Health (2006) was researched to determine their role in firefighter safety. The Firescope Firefighter Guidelines for ICS 420-1 Chapter 17 (2001) and Chapter 18 (2004), along with the State of Florida (2006) Florida Incident Field Operations Guide were used to determine which NFPA guidelines must be followed for accountability of firefighters. The City of Stuart Tactical Guidelines was reviewed to see if they met NFPA Standards (City of Stuart, 2001).

The National Institute of Occupational Safety and Health, Death in the line of duty reports (2005 and 2006), along with the United States Fire Administrative Federal Emergency Management Agency's Fatality Reports (2005 & 2006) gave vital information as to how fatalities occurred in fires and what possible accountability improvements could be made to prevent this from happening in the future.

An on-line search located articles about firefighter accountability, and the pros and cons of different systems. Fire officers had written documents on their own beliefs on different accountability systems (Carter, 2005; Tobia, M. 2005; Walker, C.A., 2006; Whelan, M.A., 2001; and Yaccich, T. A., 2006). A search of personnel accountability systems located many manufactures and the benefits of their systems. (Beyer, 2006a;

FieldSoft, 2002; FieldSoft, 2003; Grace Industries, Inc. 2006a, 2006b, & 2006c; and Scott Health and Safety, 2006).

Upon meeting Mr. Beyer on the flight to the National Fire Academy on December 11, 2005, it was determined that together we might be able to assist each other. He would provide me with a product that might lead to a new firefighter accountability system, and I would provide him with the needed data to produce such a system (personal communications, December 11, 2005). Together we have worked for months on his development of this technology. On January 18, 2006, we went to the dispatch center and talked to each of the individuals that work with the software and hardware. On that day we also spoke to the shift workers that work with the PDAs on the street. Mr. Beyer asked many technical questions that could only be answered by the technicians of the individual programs (personal communications, January 18, 2006).

Several personal interviews and phone conversations with Malcolm Beyer, Jr. and Scott Brown of Advanced Ground Information Systems, Inc. were conducted over the months of January and February, in order to discuss the design of software, which would fulfill the needs of a firefighter emergency operations accountability system. It was determined that Mr. Beyer could design a system and patent it so that many people can talk to each other, such as a conference call or radio broadcast, by pointing at each user's symbol and pressing the call key. The system runs on PDA cellular phones such as a Treo (a line of smartphones that have a number of integrated features making it possible to check the calendar while talking on the phone, dial directly from contacts list, send emails, and on recent models take pictures as defined in web definitions, 2006). The system is designed to move from screen to screen by the touch of a button. Each screen

will have several different features. The system is compatible with other emergency medical services software, such as: dispatch software, medical report writing software, and global positioning software. The system has just been patented and is in the trial stages at this point. The City of Stuart will be among the first users to try out the system by measuring the reliability and usability of the system for first responder accountability (personal communications, January 18, 2006 and February 14, 2006).

It appears as though no one accountability system can do it all. If we choose to use electronic equipment we must assume that it will not work 100% of the time. As we all know electronics are not 100% accurate and do not work 100% of the time (U.S. Fire, 1999). The older, non-electronic versions of accountability systems rely on humans. There is always the possibility of human errors. Many firefighters forget to turn on their PASS devices as we have read (Walker, 2006). The accountability officer may not be able to track all of the information due to the size of the scene and the lack of assistance (Tobia, 2005). Firefighters may lose radio communications for some reason or another, they may not stay with their partner, and/or they may lose connection with their lifeline (NIOSH, 2006b).

Results

To answer the first question of: What types of electronic accountability systems are available to fire rescue personnel? Based on the literature review, there are several manual types of accountability systems, such as: radio rollcall, clipboard and paper, white board, ring-based, hook and pile, card-punch technology. Some electronic and radio types of accountability are based on: bar-code technologies, radio technology, radio-transmission-based accountability systems, radio-frequency identification accountability

system, and GPS-based accountability systems. Personal alert safety system devices include: SCBA-integrated PASS, partially and fully integrated units, temperature-sensitive PASS devices, electronic-transmitting PASS devices, and key-activated PASS devices. The Electronic status monitors are mainly used with the military and have not become commercially available to the fire service at this time. There are also accountability aids, such as: sound-based exit devices, thermal imaging technology, personal thermal imaging cameras, forward-looking infrared radar, reflective hose, reflective and lighted rope, reflective clothing, and light indicators. Communications are one of the most needed devices in accountability. Communications devices may use: radio frequency systems, trunked radio systems, hardwired communications systems, communications wire/rope, wireless underwater radios, water-resistant communications equipment, cellular and satellite technology, portable repeaters, or real-time video transmitters (U.S. Fire, 1999).

The second question is: What is the reliability of the Stuart Fire Rescue's current accountability systems? Compared to the literature review by Carter, Tobia, Walker, Whelan, and Yaccich, it would appear as though the City of Stuart Fire Rescue fairs well with the current systems they use. Chief Carter suggests the three-tag system (Carter, 2005). The City of Stuart Fire Rescue currently uses a tag system very similar to the one suggested by Chief Carter. It is used on every structure fire and every emergency scene that multiple units are arriving and accountability system is warranted. It is not used on routine medical calls.

Walker's research found that at times firefighters have been known to not activate their PASS devices (Walker, 2006). The T-PASS II device by Grace Industries solves

that problem by automatic activation. It also will allow firefighters the ability to send a distress signal either manually or the device will be "automatically activated if the firefighter is injured and ceases movement" (Grace, 2006a, ¶3). The City of Stuart uses a PASS device produced by MSA integrated the PASS activation when the air bottle is turned on. The system also uses a heads-up display, which integrates the air quantity into the facemask. This system will activate if the firefighter is injured and ceases movement, or be manually activated. This system does not have a receiving monitor for command, as does the Scott Electronic Management System (Scott, 2006).

As research has suggested, the FDonScene software, by FieldSoft, Inc. will provide "each person with the ability to send an emergency alert to the command post" (FieldSoft, Inc., 2003, ¶5). The City of Stuart firefighter and police officers have all been issued a Motorola radio that has a unique identity for each individual. The radio has an emergency alert button, that if pushed will activate an alarm on the dispatch console. The dispatcher notifies all personnel to only allow emergency communications, and identifies whose emergency alert has been activated.

Captain Whelan stands by the bar-coding system. He believes it is the answer to multiple jurisdictions and can expand quickly and easily (Whelan, 2001). The City of Stuart does not incorporate a bar-coding system within their gear.

To meet the NFPA 1500 and 1561 Standards, and Firefighter Guidelines for Incident Command Systems (ICS) 420-1, the City of Stuart does have Tactical Guidelines in place to meet the guidelines (NFPA, 2006; Firescope, 2001 & 2004; and City of Stuart, 2001).

To answer the third question of: What types of improvements can be made to electronic accountability systems to reduce firefighter deaths and injuries? Based on what Captain M. Tobia (2005, History Repeating section) writes in Fire Chief's magazine, "Who is in the building?"

Several personal interviews were held with Malcolm Beyer and Scott Brown after meeting Mr. Beyer on December 11, 2005. Mr. Beyer, Chairman of Advanced Ground Information Systems Inc., is developing a product that we believe will enhance the firefighter accountability systems in place. The system, when used with GPS will allow tracking of individuals at all times. When tracking the firefighter outside the building, the accuracy should normally be within approximately 10 feet. When a person is within a structure, the GPS locations may not be accurate, and can vary outside of ten-foot area. Furthermore, once inside the building, the GPS signals bounce off the walls creating a multi-path condition, which causes varying positional data to be received. GPS height information is not accurate enough to determine the floor location. However, it is believed that this is the wave of the future as additional electronic tracking methods are being developed by industry and the military to augment GPS to track inside buildings and tunnels. If personnel could be tracked on a location map within a structure, even if within ten feet, then command would have the ability to quickly locate a distressed firefighter. Having the firefighter say his assumed floor level can augment height location.

Yaccich's report that states, "In my eyes, electronic systems are tools, nothing more. You still need a human to operate it. I guess what I am saying is, it is more important to have a good accountability officer to run your system, than it is to have an

elaborate system" (Yaccich, 2006, ¶6). Based on the comments of Yaccich, the City of Stuart Fire Rescue fairs well, due to its knowledgeable firefighters and officers. However, the City does have a shortage of manpower, which can prove to be detrimental on an emergency scene.

Discussion

Through the literature process, it was found that Chief Carter has faith in the accountability tag system (Carter, 2005). It appears that the accountability tag system should be a vital part of any accountability system. When the tags are collected and mounted to an accountability board, the job of accountability and tracking is much clearer.

Just as Mr. Walker expresses his concern for PASS activation, Grace Industries and Scott Health and Safety have been working to improve the safety of the PASS devices (Walker, 2006; Grace, 2006; Scott, 2006). The City of Stuart Fire Rescue Department has already taken steps towards improving the chances of a firefighter not activating their PASS device. Within the past year, the department upgraded all MSA packs to integrate the PASS device in the air valve mechanism. The Scott Electronic Management System has taken this one step further, where command can read and track, through a receiving monitor, the quantity of every firefighter's on-scene air (Scott, 2006). The T-PASS II also allows command to see if a firefighter has set off an alarm and is in distress (Grace, 2006). The visual monitoring of these two systems allows the accountability officer to view a firefighter in distress, and appears to be another useful tool in the toolbox, as Yaccich (2006) suggests.

The FDonScene software that was designed to work with the Motorola radio to use an activation button to alert command when in distress is an extremely important advance in communications accountability (FieldSoft, 2003). The City of Stuart agrees with this concept, and has purchased a Motorola radio with an emergency alert button for every person in the department. The radios are individually assigned with an identification code when activated. The concept of good communication on an emergency scene is of the utmost importance.

Captain Whelan strongly supports the use of the bar-coding system. He stated that it was easy to use and can quickly adapt to mutual aid arrivals (Whelan, 2001). This system has not been evaluated by the City of Stuart Fire Rescue, and may be beneficial since they are a small department and frequently rely on mutual aid assistance when responding to a large incident. The City uses the same accountability tag system as the responding county. The benefit of the bar-coding system is that when a firefighter arrives from the neighboring jurisdiction and is scanned, vital information about the firefighter becomes available to command. The bar-code can contain information about the person's qualifications and skills. This information could be very useful during a stressful situation. The computer could identify who was available for the specific operational needs. The bar-coding system also assists in run reports. "The operator can call up a template for a run report and get a head start filling in the boilerplate [common format] and other fields of report" (Whelan, 2001, Run Report section). This tool may be invaluable on large-scale incidents where it becomes difficult to remember all the agencies or personnel that responded.

Captain Tobia writes in his article, *Tags, Not It?*, "The cost of the system does not translate into effectiveness either; neither a cow tag clipped to a D-ring not a multi-faceted, integrated, connected, electronic tone-sounding, temperature-taking tool will tell the incident commander who is in the building at any given moment" (Tobia, 2005, ¶3). This concept of not being able to see where people are within a structure is what brought about the idea of a better electronic system. Mr. Beyer, with this *Many-to-Many* technology, has brought in some interesting concepts that just may in time prove to be the type of electronic system fire service is looking for. The chances of being able to look at a PDA and track where others are located within a relatively small area are very appealing for a fire service accountability system. Mr. Beyer has the beginnings of a system that in time will be a must for the fire service. His system will allow others to selectively talk to many others at the same time, which can be very beneficial to an emergency call. The down side is that the call will not be recorded through dispatch. The system will be able to move into map tracking screens so that any individual within the system can be tracked to their location and given directions to an emergency call. When they arrive on the call, command could change the screen again to bring up the map of the building and track the movement of the people within the building. The downside of this is that you must already have the floor plan in place and the person inside must have a tracking device on them. Most firefighters do not carry cellular phones on them when going into a structure fire. If GPS technology could be built into a PASS device, command would have total visibility of each firefighter. Mr. Beyer's system is just in the beginning phase of the future of the fire service. It is believed that it will start a new trend in firefighter accountability (Beyer, 2006a).

Recommendations

Several firefighter accountability systems have been identified in this research. However, it appears that there is no one system that can do it all. Firefighters must continually strive for better products that can lead to safer procedures. Firefighters must take accountability seriously and use every device available to them accurately.

As Captain Tobia (2005, ¶2) states, "The two primary goals of an incident commander at a fire are always the same: to play a positive role in solving the customer's problem and to bring all firefighters home safely." It could not have been said any better. Firefighters must need to always strive for better and safer ways to bring all firefighters home safely.

As far as the City of Stuart's accountability systems, it appears as though they all work nicely together and provide a bit of security; however, one must always continue to look for improvements in safety. The City of Stuart will continue to work with Mr. Beyer in the development of an accountability system that will track and communicate with people within a structure. As electronics continually improve, it is believed that his, and similar systems, will be the start of a new trend.

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